

EXHIBIT "G"
Castle Bravo Experiment

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Castle Bravo

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Castle Bravo



Castle Bravo mushroom cloud.

Type	<u>Thermonuclear weapon</u>
Place of origin	<u>United States</u>
Production history	
Produced	<u>24 February 1954 (GMT)</u>
Number built	<u>1</u>
Specifications	
Weight	<u>23,500 lb</u>
Length	<u>179.5</u>
Width	<u>53.9</u>
Height	<u>100,000</u>
Diameter	<u>6510</u>
Blast yield	<u>15 megatons</u>

Castle Bravo was the code name given to the first U.S. test of a so-called dry fuel thermonuclear hydrogen bomb device, detonated on March 1, 1954 at Bikini Atoll, Marshall Islands, by the United States, as the first test of Operation Castle (a longer series of tests of various devices). Fallout from the detonation—intended to be a secret test—poisoned the islanders who inhabited the test site, as well as the crew of *Daigo Fukuryū Maru* ("Lucky Dragon No. 5"), a Japanese fishing boat, and created international concern about atmospheric thermonuclear testing.

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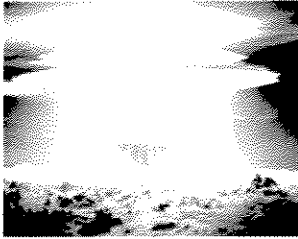
The bomb used [lithium deuteride](#) fuel for the [fusion](#) stage, unlike the [cryogenic liquid deuterium](#) used as fuel for the fusion stage of the U.S. first-generation [Ivy Mike](#) device, which, being the size of a small office building, was an impracticable weapon for use at war. The bomb tested at Castle Bravo was the first practical deliverable [fusion bomb](#) in the U.S. arsenal.

The [Soviet Union](#) had previously used lithium deuteride in a [nuclear bomb](#), their [Sloika](#) (also known as Alarm Clock) design, but since it relied on using the initial fission explosion to compress, inertially confine, and ignite the fusion fuel, its [yield](#) was limited (400 kt) in comparison to the [Teller-Ulam](#)-based Ivy Mike (10.4 Mt) and Castle Bravo (~15 Mt). Mike and Bravo both used the [Teller-Ulam design](#), which featured separation of the fusion device from the fission device, and used radiation pressure (or probably radiation-induced ablation of the heavy tamper surrounding the fusion device) to produce staged-radiation implosion and fusion ignition of a much greater magnitude. After a few years, the Soviets, led by [Andrei Sakharov](#), independently [developed](#) and [tested](#) their first [Teller-Ulam](#) device in 1956.

Castle Bravo was the most powerful [nuclear device](#) ever detonated by the United States, with a yield of 15 [megatons](#). That yield, far exceeding the expected yield of 4 to 6 megatons, combined with other factors to produce the worst [radiological accident](#) ever caused by the United States.

In terms of TNT tonnage equivalence, Castle Bravo was about 1,000 times more powerful (4-8 times larger, on a logarithmic scale) than the atomic bombs which were [dropped](#) on [Hiroshima](#) and [Nagasaki](#) during [World War II](#). The largest nuclear explosion ever produced was a test conducted by the [Soviet Union](#) several years later, the ~50 Mt [Tsar Bomba](#).

[edit] **Design and detonation**



The Castle Bravo mushroom cloud.

The device detonated for the test was named "Shrimp" and was the same basic configuration as the Ivy Mike device, except with a different kind of fusion fuel. This device also implemented a light case design, using aluminum instead of the heavy steel case used in Mike.

Inside a cylindrical case was a smaller cylinder of lithium deuteride fusion fuel (the secondary) with a regular fission atomic bomb (the primary) at one end; the latter was used to create the conditions needed to start the fusion reaction. Running down the center of the secondary was a cylindrical rod of plutonium (the sparkplug), which was used to ignite the fusion reaction. Surrounding this assembly was a natural uranium tamper; the space between the tamper and the case formed a radiation channel to conduct X-rays from the primary to the secondary. The function of the X-rays was to compress the secondary (by various means; see Teller-Ulam design), increasing the density and temperature of the deuterium to the levels needed to sustain the thermonuclear reaction, and compressing the sparkplug to supercriticality ignition.

It was practically identical to the "Runt" device later detonated in Castle Romeo, but used partially enriched lithium in the fusion fuel. Natural lithium is a mixture of lithium-6 and lithium-7 isotopes (with 7.5% of the former); the enriched lithium used in Bravo was approximately 40% lithium-6. The primary was a standard RACER IV fusion-boosted atomic bomb.





The Shrimp device, silhouette added for scale.

The device was a very large cylinder weighing 23,500 pounds (10.7 tonnes) and measuring 179.5 inches (4.56 m) in length and 53.9 inches (1.37 m) in width. It was mounted in a "shot cab" on an artificial island built on a reef off Namu Island, in the Bikini Atoll. A sizeable array of diagnostic instruments were trained on it, including a

number of high-speed cameras which were trained through an arc of mirror towers around the shot cab.

When Bravo was detonated, it formed a fireball almost four and a half miles (roughly 7 km) across within a second. This fireball was visible on the Kwajalein atoll over 250 miles (450 km) away. The explosion left a crater of 6,500 feet (2,000 m) in diameter and 250 feet (75 m) in depth. The mushroom cloud reached a height of 47,000 feet (14 km) and a diameter of 7 miles (11 km) in about a minute; it then reached a height of 130,000 feet (40 km) and 62 miles (100 km) in diameter in less than 10 minutes and was expanding at more than 6 kilometers (4 miles) per minute.

Coordinates for Bravo Crater are  11°41'50"N, 165°16'19"E. The coordinates for remains of Castle Bravo causeway are  11°42'6"N, 165°17'7"E.

The detonation took place at 06:45 on March 1 local time (18:45 on February 28 GMT).^[1]

[edit] Cause of high yield

The yield of 15 megatons was two and a half times what was expected. The cause of the high yield was a laboratory error made by designers of the device at Los Alamos National Laboratory.

It was expected that lithium-6 isotope would absorb a neutron from the fissioning plutonium, emit an alpha particle and tritium in the process, of which the latter would then fuse with deuterium (which was already present in the LiD) and increase the yield in a predicted manner.

The designers missed the fact that when the lithium-7 isotope (which was considered basically inert) is bombarded with high-energy neutrons, it absorbs a neutron then decomposes to form an alpha particle, another neutron, and a tritium nucleus. This means that much more tritium was produced than expected, and the extra tritium in fusion with deuterium (as well as the extra neutron from lithium-7 decomposition) produced many more neutrons than expected and induced more fission of the uranium tamper, increasing yield.

This resultant extra fuel (both lithium-6 and lithium-7) contributed greatly to the fusion reactions and neutron production, and in this manner greatly increased the device's yield. The test used lithium with a high percentage of lithium-7 only because lithium-6 was (at the time) scarce and expensive; the later Castle Union test used almost pure lithium-6. Had more lithium-6 been available, the usability of the common lithium-7 might not have been discovered.

Of the total 15-megaton yield, 10 megatons were from fission of the natural uranium tamper.

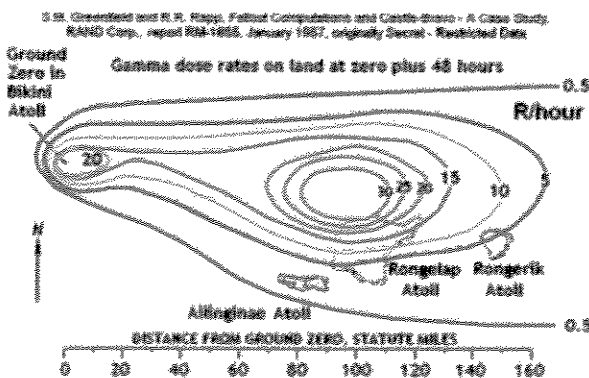
the fishing vessel disagreed with this. Sir Joseph Rotblat, working at St Bartholomew's Hospital, London, demonstrated that the contamination caused by the fallout from the test was far greater than that stated officially. Rotblat was able to deduce that the bomb had three stages and showed that the fission phase at the end of the explosion increased the amount of radioactivity a thousandfold. Rotblat's paper was taken up by the media, and the outcry in Japan reached such a level that diplomatic relations became strained and the incident was even dubbed by some as "a second Hiroshima"^[citation needed]. Nevertheless, the Japanese and U.S. governments quickly reached a political settlement which gave the fishery a compensation of 2 million dollars with the surviving victims receiving between 1.91 million yen and 2.29 million yen each. It was also agreed that the victims would not be given Hibakusha status.

Unanticipated fallout and radiation also affected many of the vessels and personnel involved in the test, in some cases trapping them in bunkers. One prominent scientist later recalled that he was on a ship 30 miles (48 km) away, and received 10 Röntgen of radiation as a result. Sixteen crew members of the aircraft carrier USS Bairoko received beta burns and there was a greatly increased cancer rate. Radioactive contamination also affected many of the testing facilities built on other islands of the Bikini atoll system.

The fallout spread traces of radioactive material as far as Australia, India and Japan, and even the US and parts of Europe. Though organized as a secret test, Castle Bravo quickly became an international incident, prompting calls for a ban on the atmospheric testing of thermonuclear devices.^[3]

In addition to the radiological accident, the unexpectedly high yield of the device severely damaged many of the permanent buildings on the control site island on the far side of the atoll. Very little of the desired diagnostic data on the shot was collected; many instruments designed to transmit their data back before being destroyed by the blast were instead vaporized instantly, while most of the instruments that were expected to be recovered for data retrieval were destroyed by the blast.

[edit] Later devices



A formerly secret Rand Corporation simulation of the Castle Bravo fallout indicating that high levels on Rongelap may have been due to a hotspot. Hotspots downwind are typical

of bursts on coral in humid atmospheres, and also occurred in the 1954 *Yankee* and *Nectar* water surface bursts, and the 1956 coral surface bursts *Zuni* and *Tewa*.

The Shrimp device design later evolved into the Mk-21 bomb, of which 275 units were produced, weighing 15,000 pounds (6,800 kg) and measuring 12.5 feet (3.8 m) long and 56 inches (1.4 m) in diameter. This 4 megaton bomb was produced until July 1956. In 1957, it was converted into the Mk-36 and entered into production again.

[edit] See also

- History of nuclear weapons
- Operation Ivy

[edit] References

1. [^] "Nuclear Weapon Archive". Retrieved on 2008-03-01.
2. [^] "Nuclear Issues". Retrieved on 2006-03-26.
3. [^] DeGroot 2004, pp. 196-198
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 - Republic of the Marshall Islands Embassy website
 - Cronkite E. P., Conard R. A., Bond V. P. (1997). "Historical events associated with fallout from Bravo Shot - Operation Castle and 25 Y of medical findings". *Health Physics* **73** (1): 176–186. doi:10.1097/00004032-199707000-00014.

[edit] External links

- Video of the Castle Bravo shot at sonicbomb.com
- Downloadable/Streamable Declassified Film: Operation Castle Commanders Report, at the Internet Archive
- Downloadable/Streamable Declassified Film: Military Effects Studies Operation Castle, at the Internet Archive
- Operation Castle
- US tests hydrogen bomb in Bikini (BBC News)
- First-person article about conducting the test
- Compilation Video of Operation Castle shots on google video

Coordinates:  [11°41′50″N, 165°16′19″E](#)

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